

A new species of *Simulium* (*Boreosimulium*) from Hokkaido, Japan (Diptera: Simuliidae)

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Abstract: *Simulium* (*Boreosimulium*) *tokachiense* sp. nov. is described on the basis of adults, pupae and mature larvae collected in Tokachi, Hokkaido, Japan. This is the second species of the subgenus *Boreosimulium* from Japan, and is most similar to *S. (B.) balteatum* described from North America by having the paramere with one medial and three apical hooks, the style with the dorsomesal margin bulged, and the pupal gill with the dorsal stalk branching near the middle of the gill. However, this new species is distinguished in the pupa by the gill with the ventral stalk very short and in the larva by the antenna without hyaline bands and the abdomen with a weakly colored transverse band on each segment.

Key words: *Simulium*, black fly, Simuliidae, Japan, description, *Boreosimulium*

The subgenus *Simulium* (*Boreosimulium*) (Rubtsov and Yankovsky) is a small group distributed in the Holarctic Region (Adler et al., 2004), and is represented by only one species, *S. (B.) kono* (Takahasi), in Japan (Sato et al., 2004). Recently, another species belonging to this subgenus was collected from Hokkaido in Japan. It is described as a new species based on the adult, pupal and larval stages.

The terms for morphological features used here follow those of Takaoka (2003). Holotype and paratype specimens of the new species are deposited at the Department of Infectious Disease Control, Oita University.

Simulium (*Boreosimulium*) *tokachiense* sp. nov.

DESCRIPTION. Female. Body length about 2.6 mm. **Head.** Narrower than thorax. Frons brownish-black, thickly whitish-grey pruinose, very slightly shiny at certain angle of light,

moderately covered with whitish-yellow recumbent hairs except medial longitudinal portion narrowly or moderately bare, interspersed with 0-2 dark brown hairs along each lateral margin. Frontal ratio 1.3 : 1.0 : 1.1-1.3. Frons-head ratio 1.0 : 4.0-4.7. Fronto-ocular area (Fig. 1A) well developed, triangular, directed laterally and slightly upwardly. Clypeus brownish-black, thickly whitish-grey pruinose, very slightly shiny at certain angle of light, and moderately covered with whitish-yellow recumbent hairs except medial portion of upper 1/2 widely bare. Labrum 0.65-0.70 times as long as clypeus. Antenna composed of 2+9 segments, entirely brownish-black; 1st flagellar segment about 1.4 times as long as 2nd one. Maxillary palp consisting of 5 segments, blackish, proportional lengths of 3rd, 4th, and 5th segments 1.00 : 0.96 : 1.77; 3rd segment (Fig. 1B) of moderate size, with sensory vesicle elongate, 0.33 times as long as 3rd segment, with medium-sized opening. Maxillary lacinia with 9-11 inner and 18 outer teeth. Mandible with 24 inner and 9 outer teeth. Cibarium (Fig. 1C)

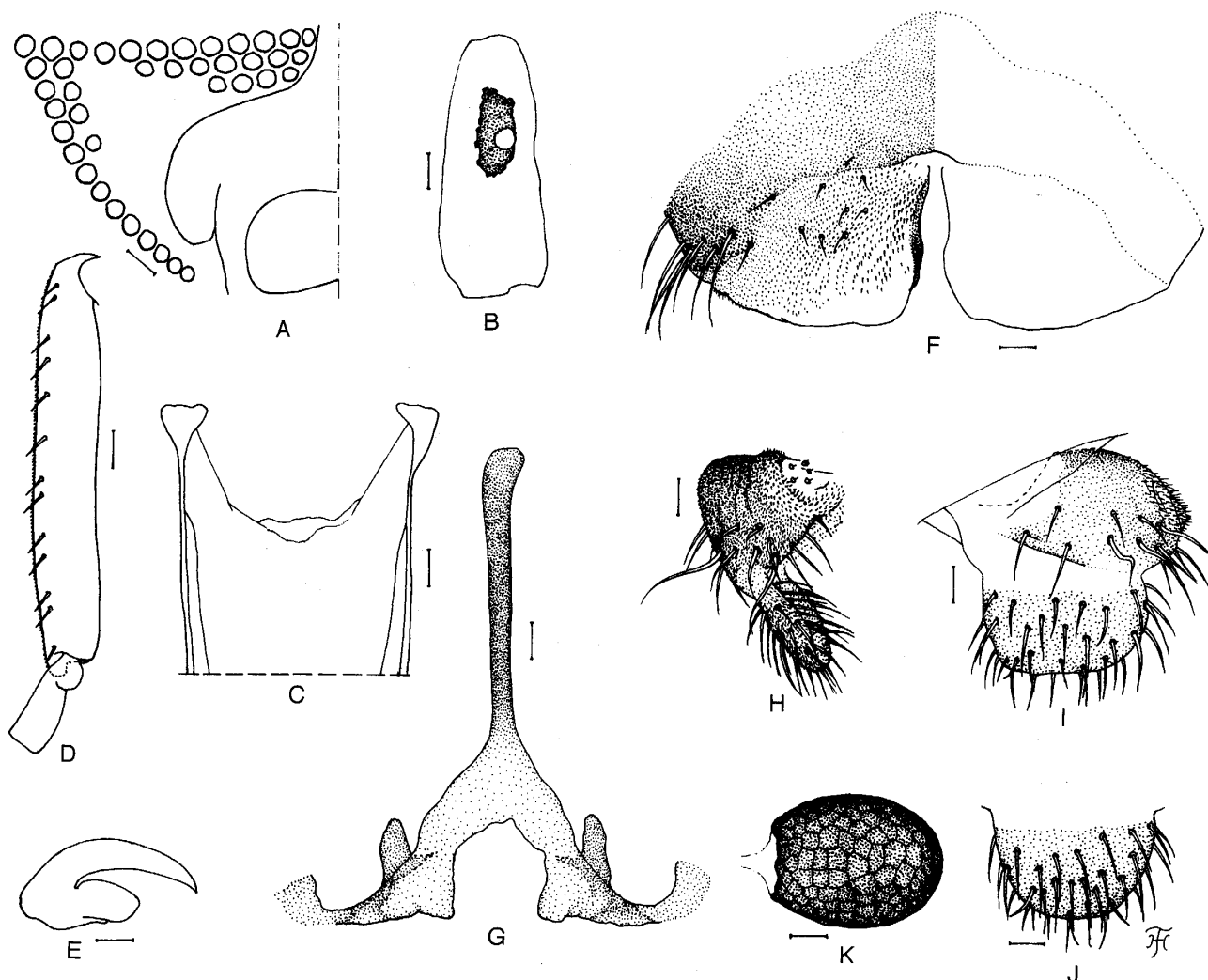


Fig. 1. Female of *Simulium* (*Boreosimulium*) *tokachiense* sp. nov. A, fronto-ocular area (right side); B, 3rd segment of maxillary palp with sensory vesicle (right side, front view); C, cibarium; D, basitarsus and second tarsal segment of hind leg showing calcipala and pedisulcus (left side, outer view); E, claw; F, 8th sternite and ovipositor valves *in situ* (ventral view); G, genital fork; H and I, paraprocts and cerci *in situ* (right side; H, ventral view; I, lateral view); J, cercus (right side, lateral view); K, spermatheca. Scale bars. 0.05 mm for D; 0.02 mm for A-C and F-K; 0.01 mm for E.

smooth near posterodorsal margin. **Thorax.** Scutum brownish-black to black, slightly shiny at certain angle of light, densely covered with brilliant yellowish-white recumbent hairs, and with several dark brown upright hairs on prescutellar area. Scutellum brownish-black, with several dark brown upright hairs as well as yellowish-white shorter hairs. Postnotum brownish-black, shiny at certain angle of light and bare. Lateral surface of thorax brownish-black, shiny at certain angle of light and bare. Pleural membrane medium brown and bare. Katepisternum longer than deep, brownish-black and bare. Furcasternum without apodeme directed downwards on each arm. **Legs.** All brownish-black to black except small

area of pedisulcus paler; coxae, trochanters, femora and tibiae moderately to densely covered with brilliant yellowish-white hairs mostly on outer surface; fore basitarsus slender, slightly dilated, 6.8 times as long as its greatest width; hind basitarsus (Fig. 1D) nearly parallel-sided, 6.67 times as long as wide, and 0.69 and 0.53 times as wide as greatest widths of hind tibia and femur, respectively; calcipala well developed, nearly as long as wide, and 0.32 times as wide as hind basitarsus; pedisulcus well developed. Claw (Fig. 1E) with large basal tooth 0.55 times as long as claw. **Wing.** Length 2.5 mm. Costa with 2 parallel rows of dark short spinules as well as dark hairs except basal portion of costa with patch of whitish

hairs. Subcosta with dark hairs throughout its length. Basal portion of radius fully haired; R_1 with dark spinules and hairs; R_2 with dark hairs. Hair tuft on stem vein composed of whitish hairs and dark brown hairs. Basal cell absent. **Abdomen.** Basal scale brownish-black, with fringe of yellow long hairs. Dorsal and lateral surfaces of abdomen dark brown to brownish-black, moderately to densely covered with whitish-yellow short hairs (though dorsal surface of segments 3 and 4 sparsely covered) interspersed with dark ones on posterior segments; all tergites not shiny; tergites 3–6 nearly quadrate, tergite 7 shorter than wide, occupying 1/2 of dorsal surface of segment 7, and tergites 8 and 9 very wide, occupying entire surface of their segments. Ventral surface of abdomen light to dark brown; segment 7 with large sternal plate medially. **Genitalia.** Sternite 8 (Fig. 1F) wide, bare medially but furnished with 10–17 short and medium-long hairs on each side. Ovipositor valves (Fig. 1F) triangular, thin, membranous except inner margin narrowly sclerotized, densely covered with microsetae (except near posterior margin bare) interspersed with 7–10 short hairs; inner margins slightly concave medially and narrowly separated from each other. Genital fork (Fig. 1G) of inverted Y-form, with well sclerotized stem and wide arms; each arm with wide lateral plate having prominent projection directed forward. Paraproct in ventral view (Fig. 1H) with unsclerotized medial area deeply and broadly concave having 8 or 9 sensilla; paraproct in lateral view (Fig. 1I) somewhat protruding ventrally beyond level of cercus. Cercus in lateral view (Fig. 1I, J) rectangular or rounded posteriorly, 0.67 times as long as wide. Spermatheca (Fig. 1K) ovoidal, strongly sclerotized except area around juncture to duct and duct itself unsclerotized, with distinct polygonal surface pattern and without internal setae; both accessory ducts subequal in diameter to each other and also to main duct.

Male. Body length 2.7 mm. **Head.** Much wider than thorax. Holoptic; upper eye consisting of large facets in 21 vertical columns and 21 horizontal rows. Clypeus black, not shiny, whitish-grey pruinose, moderately covered with dark simple hairs. Antenna composed of 2 + 9 segments, brownish-black to black; 1st flagellar segment elongate, about 1.8 times as long as 2nd one. Maxillary palp dark brown, composed of 5 segments, proportional lengths

of 3rd, 4th, and 5th segments 1.0 : 1.1 : 1.9; 3rd segment (Fig. 2A) of moderate size; sensory vesicle (Fig. 2A) small, ellipsoidal, 0.24 times as long as 3rd segment. **Thorax.** Scutum black, dull except areas on each shoulder, along each lateral margin and on prescutellar area shiny and whitish-grey pruinose at certain angle of light, densely covered with brilliant yellowish-white recumbent hairs interspersed with several black upright hairs on prescutellar area. Scutellum dark brown, with many black upright long hairs as well as yellowish-white shorter hairs. Postnotum brownish-black to black, shiny and whitish-grey pruinose at certain angle of light, and bare. Lateral surface of thorax brownish-black, whitish-grey pruinose. Pleural membrane bare. Katepisternum longer than deep, dark brown and bare. **Legs.** All brownish-black to black except small area of pedisulcus somewhat paler, densely covered with dark hairs mixed with whitish hairs on anterior surface of fore coxa and femur and outer surface of fore tibia; fore basitarsus slender, cylindrical, 8.9 times as long as its greatest width; hind basitarsus (Fig. 2B) nearly parallel-sided though somewhat tapered near both ends, 5.2 times as long as its greatest width, and 0.76 and 0.73 times as wide as greatest widths of hind tibia and femur, respectively; calcipala small, slightly shorter than its basal width and 0.22 times as wide as greatest width of hind basitarsus; pedisulcus well developed. **Wing.** Length 2.1 mm; other characters as in female including fully haired subcosta. **Abdomen.** Basal scale black, with fringe of light brown long hairs. Dorsal surface of abdomen brownish-black except segment 2 somewhat lighter, not shiny and moderately covered with light to dark brown simple hairs; ventral surface of abdomen light to medium brown except segment 2 white. **Genitalia.** Coxite in ventral view (Fig. 2C) rectangular, 1.7 times as long as wide. Style in ventral view (Fig. 2C) short, 0.95 times as long as coxite, bent inwardly, gradually tapered toward apex, with stout apical spine; style in lateral view (Fig. 2D) with dorsomedian margin bulged medially; style in ventrolateral view (Fig. 2E) broad, nearly parallel-sided from base to beyond middle, then abruptly twisted and tapered inwardly; style in end view (Fig. 2F) tapered inwards and with pointed apex. Ventral plate in ventral view (Fig. 2C) lamellate, much shorter than wide, well sclerotized, with anterior margin convex and

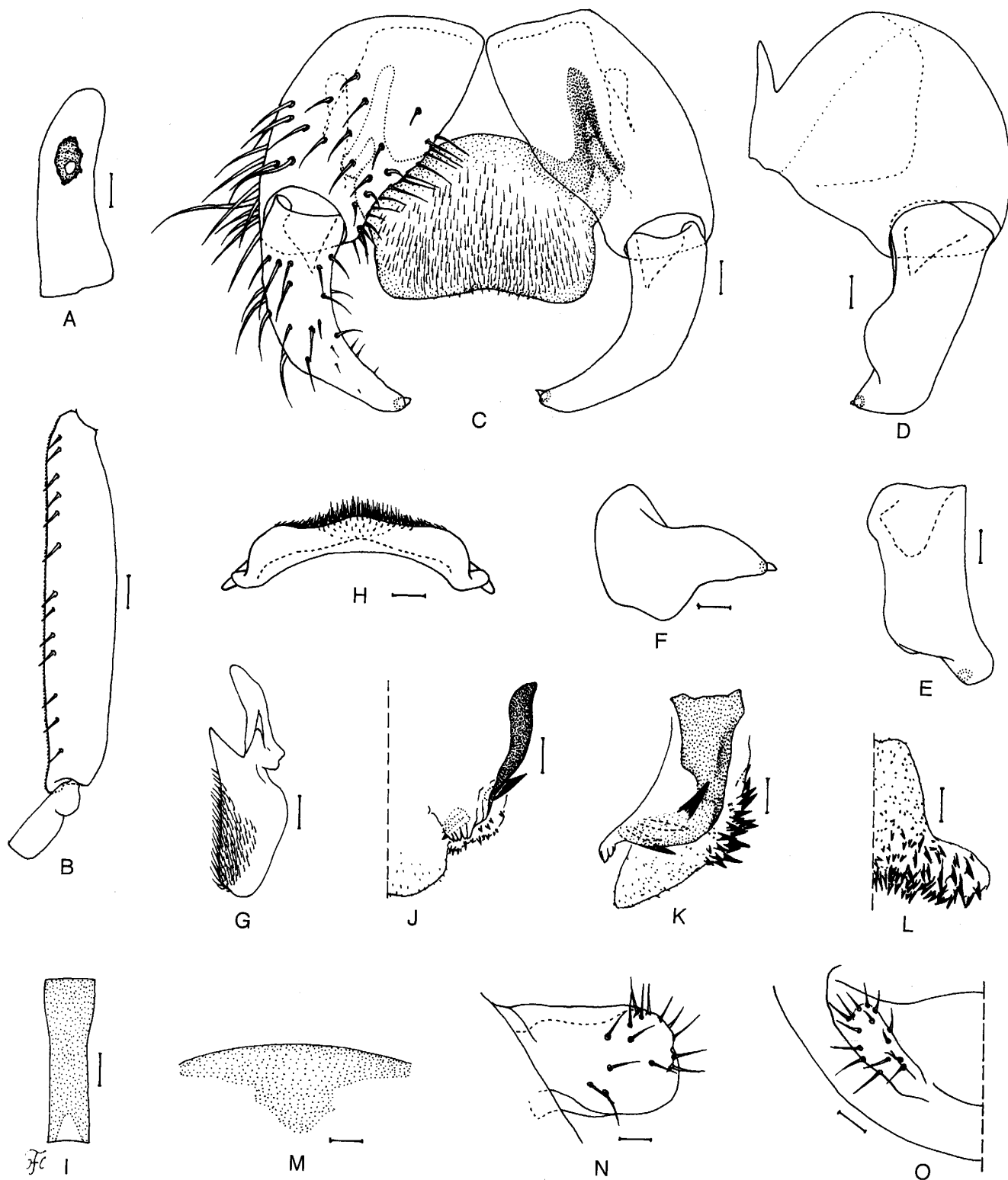


Fig. 2. Male of *Simulium* (*Boreosimulium*) *tokachiense* sp. nov. A, 3rd segment of maxillary palp with sensory vesicle (right side, front view); B, hind basitarsus and 2nd tarsal segment (left side, outer view); C, coxites, styles and ventral plate *in situ* (ventral view); D, coxite and style (right side, lateral view); E and F, styles (right side; E, ventrolateral view; F, end view); G and H, ventral plates (G, lateral view; H, end view); I, median sclerite; J and K, parameres and aedeagal membranes (left side; J, ventral view; K, lateral view); L, aedeagal membrane (end view); M, dorsal plate; N and O, 10th abdominal segments with cercus (right side; N, outer view; O, end view). Scale bars. 0.05 mm for B; 0.02 mm for A, C-O.

posterior margin concave and moderately covered with fine microsetae on ventral surface except narrow areas along anterior margin and near posterolateral corners bare; arm of moderate length, stout, directed anteriorly; ventral plate in lateral view (Fig. 2G) flat, without median keel; ventral plate in end view (Fig. 2H) with fine microsetae centrally on posterior surface. Median sclerite (Fig. 2I) simple, broad, bifurcated near apex. Paramere (Fig. 2J, K) with 1 medial and 3 apical hooks. Aedeagal membrane (Fig. 2J, K, L) moderately covered with stout spines as well as minute ones; dorsal plate (Fig. 2M) thin, with medial portion protruding posteriorly, appearing T-shaped. Ventral surface of 10th segment without distinct hairs. Cercus (Fig. 2N, O) small, narrow and encircled by 11–15 simple hairs.

Pupa. Body length 3.0–3.2 mm. **Head.** Integument (Fig. 3A) medium brown, sparsely or moderately covered with tubercles of different shapes and sizes; antennal sheaths bare; frons with 3 medium-long slender simple trichomes (Fig. 3A) on each side; face with 1 medium-long somewhat stout simple trichome (Fig. 3A) on each side. **Thorax.** Integument medium brown, sparsely or moderately covered with tubercles, with 3 long slender simple trichomes mediodorsally, 2 slender simple trichomes (1 long and 1 medium-long) mediolaterally, 1 medium-long slender simple trichome posterolaterally, and 3 medium-long slender simple trichomes ventrolaterally, on each side. Gill (Fig. 3B, C) basally composed of 3 thread-like slender filaments arising from short common basal stalk and lying vertically, decreasing in thickness from dorsal to ventral; dorsal filament bifurcated medially to further apically (1.0 mm to 1.8 mm from base) into 2 filaments of same or different length; middle and ventral filaments sharing short stalk; dorsal filament (including its branched filaments and common basal stalk) 2.5–2.8 mm long and ventral filament about 2.0 mm long; all filaments tapered towards tip, extending anteriorly close together, with distinct annular ridges and furrows and densely covered with minute tubercles. **Abdomen.** Dorsally, segments 1 and 2 entirely greyish-brown, segments 3 and 4 greyish-brown anteriorly and segment 9 yellowish; segment 1 with 1 medium-long slender simple seta on each side; segment 2 with 1 medium-long slender simple seta and 5 short spinous setae on each side; seg-

ments 3 and 4 each with 4 hooks and 2 short slender setae on each side; segments 5–9 each with spine-combs directed backward in transverse row (though no spine-combs developed in 1 female pupa) and comb-like groups of minute spines on each side; segment 9 with pair of distinct cone-shaped terminal hooks (Fig. 3D), and with or without several small tubercles. Ventrally, segments 3–8 nearly transparent, with comb-like groups of minute spines; segment 3 with a few simple minute setae on each side; segment 4 with 1 simple hook (subequal in length to those on segments 5–7) and a few simple minute setae on each side; segment 5 with pair of simple inner and bifid outer hooks submedially and a few simple minute setae on each side; segments 6 and 7 each with 1 simple or bifid hook submedially and 1 simple hook laterally and a few simple minute setae on each side. Segment 9 with 3 short simple setae on each lateral surface. **Cocoon** (Fig. 3E). Simple, wall-pocket-shaped, compactly woven without open spaces in web, thin, with anterior margin thickly woven and somewhat extending ventrolaterally; individual threads invisible; 3.7–4.5 mm long by 1.8–2.2 mm wide.

Mature larva. Body length 5.0–6.0 mm. Body (Fig. 4A) creamy white, with ochreous to light reddish-brown transverse band on each abdominal segment though usually disconnected dorsomedially. Cephalic apotome (Fig. 4B) yellow with dark broad transverse band along posterior margin; head spots medium to dark brown, well defined but posterolateral spots merged into dark band. Lateral surface of head capsule (Fig. 4C) yellow, except eye-spot region white; eyebrow light brown with 1 spot; 2 large dark spots posterior to eye-spot region merged into dark area along posterior margin in some larvae; 3 isolated spots below eye-spot region faintly to moderately positive. Ventral surface of head capsule (Fig. 4D) yellow except basal area on each side of postgenal cleft brownish-black; horizontal and round spots on each side of postgenal cleft light to medium brown. Cervical sclerite (Fig. 4B) composed of 2 small elliptical pieces, not fused to occiput, widely separated medially from each other. Antenna (Fig. 5A) consisting of 3 segments and apical sensillum, much longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.0 : 1.2 : 0.7; segments 1 and 2 light ochreous only on

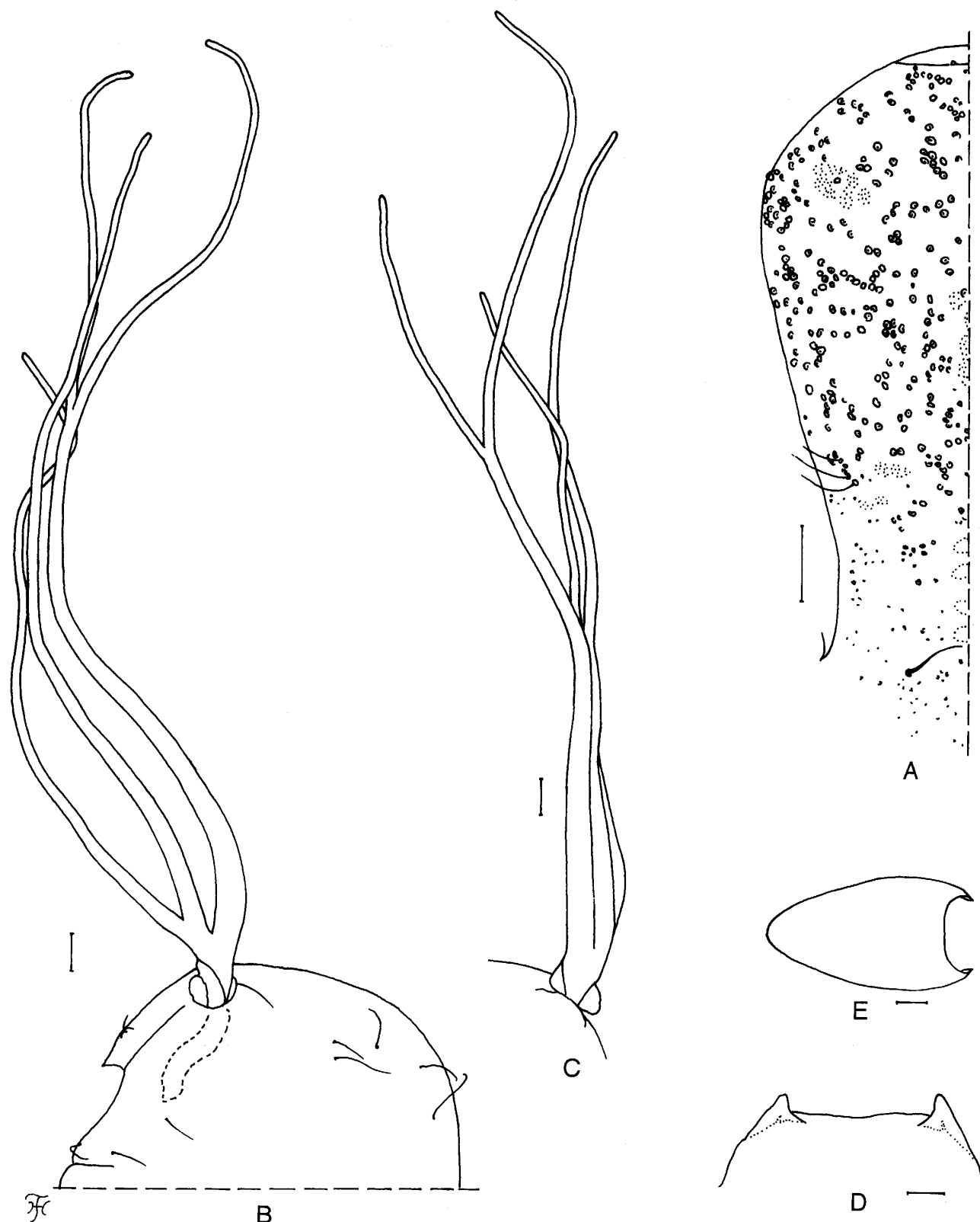


Fig. 3. Pupa of *Simulium* (*Boreosimulium*) *tokachiense* sp. nov. A, frons and upper part of face (right half); B, anterior part of thorax and gill filaments (left side, outer view); C, gill filaments (right side, dorsal view); D, terminal hooks (end view); E, cocoon (dorsal view). Scale bars. 0.5 mm for E; 0.1 mm for A-C; 0.02 mm for D.

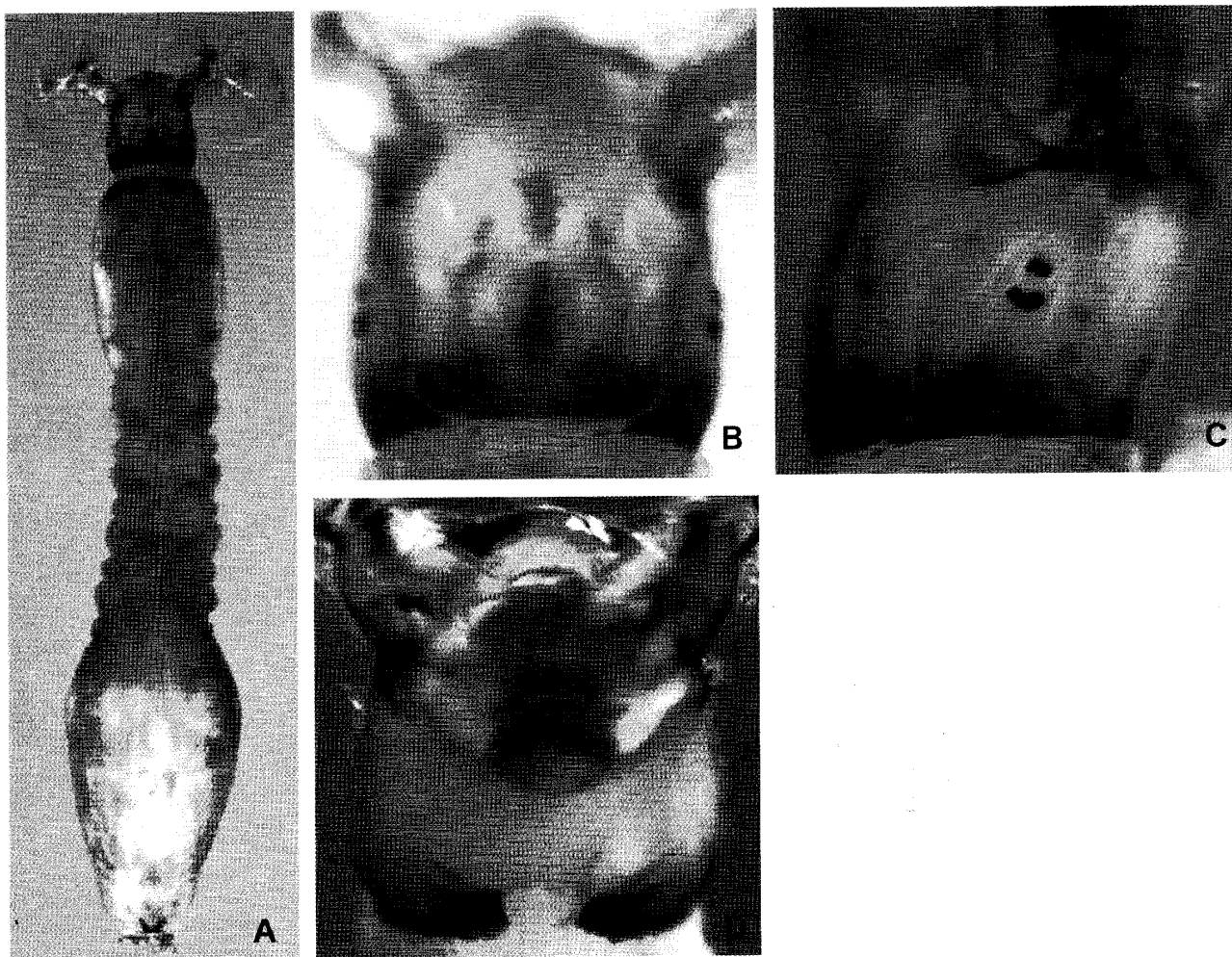


Fig. 4. Mature larva of *Simulium (Boreosimulium) tokachiense* sp. nov. A, whole body (dorsal view); B-D, head capsules (B, dorsal view; C, lateral view; D, ventral view).

outer surface, and segment 3 entirely light ochereous, and no annular hyaline hands. Labral fan with 38–43 main rays. Mandible (Fig. 5B) with mandibular serrations consisting of 2 teeth (1 large and 1 small); large tooth at right or a little less angle with mandible on apical side; comb-teeth composed of 3 teeth, 1st tooth longest, 2nd tooth a little shorter than 3rd one; 2 or 3 supernumerary serrations present. Hypostoma (Fig. 5C) with 9 apical teeth in row; median and corner teeth well developed; of 3 intermediate teeth on each side outer tooth longest and middle one shortest; lateral serrations moderately developed apically; 3 hypostomal bristles lying nearly parallel to lateral margin on each side. Postgenal cleft (Fig. 5D, E) small, nearly quadrate, with anterior margin arched or nearly straight, 0.6–0.8 times as long as postgenal bridge. Thoracic cuticle bare. Abdominal cuticle bare except both sides of anal sclerite moderately covered with simple color-

less setae. Rectal scales present. Rectal organ (Fig. 5F) of 3 compound lobes, each with 6–8 thumb-like or nodule-like secondary lobules on posterior or posterodorsal surface. Anal sclerite of usual X-form, with anterior short arms 0.8 times as long as posterior ones, broadly sclerotized at base; accessory sclerite absent. Ventral papillae well developed. Posterior circlet with about 64 rows of up to 10 hooklets per row.

TYPE SPECIMENS. Holotype male (with associated pupal exuviae and cocoon), reared from pupa, collected from a small stream crossing the national road No. 273 between Nukabira town and Mikuni Mountain Pass, Kamishihoro town, Tokachi district, Hokkaido, Japan, 5. VI.2005, by H. Takaoka, M. Fukuda and Y. Otsuka. Paratypes: 1 male, 1 female reared

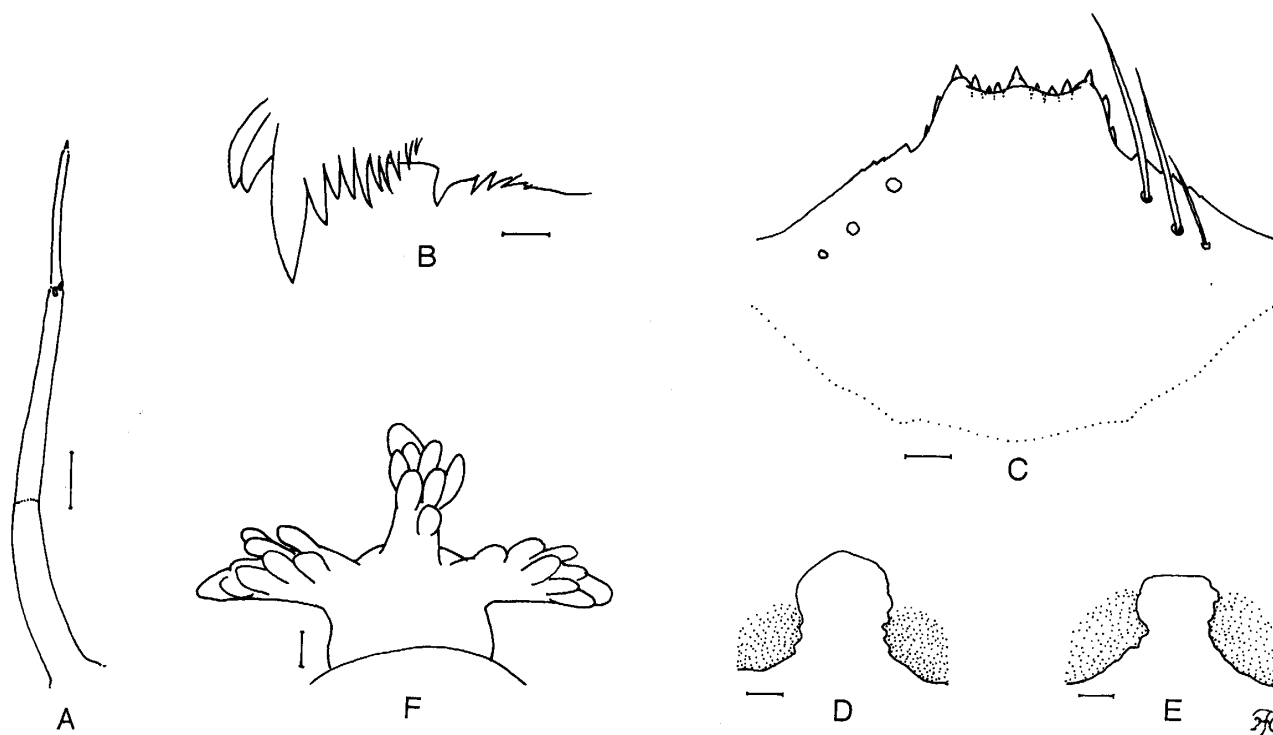


Fig. 5. Mature larva of *Simulium (Boreosimulium) tokachiense* sp. nov. A, antenna (right side, dorsal view); B, mandible; C, hypostoma; D and E, postgenal clefts; F, rectal organ (posterior view). Scale bars. 0.05 mm for A and D–F; 0.02 mm for C; 0.01 mm for B.

from pupa, 1 pupa, and 5 mature larvae, same data as those of holotype; 2 females, caught using a hand net while flying around humans at Snow Removing Station in Horoka along the national road No. 273, near the type locality, 5.VI.2005, by H. Takaoka, M. Fukuda and Y. Otsuka.

BIOLOGICAL NOTES. The pupae and larvae of *S. (B.) tokachiense* sp. nov. were found on trailing grasses in a slow-flowing small stream (width 0.4–1.0 m, water temperature 13.0°C, exposed to sun, altitude 490 m) in forest. Associated species were *Prosimulium (Prosimulium) jezonicum* (Matsumura), *Simulium (Nevermannia) uchidai* (Takahasi), *S. (N.) subcostatum* (Takahasi), *S. (Gomphostilbia) shogakii* (Rubtsov), *S. (Simulium) japonicum* Matsumura, and *S. (S.) suzukii* Rubtsov.

All the other known species of the *annulus* species-group are univoltine (Adler et al., 2004). It may be true for *S. (B.) tokachiense* sp. nov. but remains to be confirmed.

DISTRIBUTION. Japan.

ETYMOLOGY. The species name *tokachiense* refers to Tokachi district, where this new species was collected.

REMARKS. *Simulium (B.) tokachiense* sp. nov. is assigned to the Holarctic subgenus *Simulium (Boreosimulium)* redefined by Adler et al. (2004) by having the combination of the following characteristics: the female genital fork with each arm expanded into large lateral plate bearing prominent, anteriorly directed projection (Fig. 1G), the male ventral plate flat (Fig. 2C), the paramere with 1 medial and 3 apical hooks (Fig. 2K), the aedeagal membrane covered with stout small spines (Fig. 2L), the pupal gill with four filaments (Fig. 3B, C) and the larval postgenal cleft small (Fig. 5D, E). The larvae of all known species of *Boreosimulium* have hyaline bands on their antennae (Adler et al., 2004). Therefore, the present new species is unique in lacking this character state.

Within the subgenus, this new species is further classified in the *annulus* species-

group defined by Adler et al. (2004) in that it has the male ventral plate without medial keel, the dorsal plate broadly triangular (Fig. 2M), the cocoon without anterodorsal projection (Fig. 3E), and the larval hypostoma with anterior teeth of rather uniform size (Fig. 5C).

Simulium (B.) tokachiense sp. nov. seems to be most similar to *S. (B.) balteatum* described from North America (Adler et al., 2004) by having the paramere with one medial and three apical hooks, the style with dorsomesal margin bulged (Fig. 3D), the pupal gill with the dorsal stalk branching near the middle of the gill (Fig. 3B, C). However, this new species is distinguished in the pupa by the gill with the ventral stalk very short (Fig. 3B) and in the larva by the abdomen with a weakly colored transverse band on each segment (Fig. 4A) as well as the antenna without hyaline bands (Fig. 5A).

This is the second species of the subgenus *Boreosimulium* recorded from Japan, and is readily distinguished from *S. (B.) konoï*, the only other known Japanese species of this subgenus, in the female by the dark legs and the cibarium without any clustered processes (Fig. 1C), in the male

by the entirely dark antenna, in the pupa by the gill with a very long dorsal stalk branching near the middle of the gill and in the larva by the small postgenal cleft and the antenna without hyaline bands.

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